Building Research Establishment Digest

CI/SfB 1976 (K4)	DIGEST 233

January 1980

Fire hazard from insulating materials

As a consequence of energy crises, demands for better thermal insulation have inevitably increased and provided a basis for the expansion of the insulating materials industry. Not only has the production of existing materials increased substantially over the last few years, some new products have appeared which in some cases offer substantial cost benefits. The Homes Insulation Scheme 1978, which gives encouragement to the use of loft insulation in domestic buildings, and the Building (First Amendment) Regulations 1978, which on 1 June 1979 extended the requirements for thermal insulation to buildings other than dwellings, will further increase the demands for thermal insulating materials.

This digest discusses the behaviour of insulating materials under fire conditions and offers advice on their use so that increased comfort is not necessarily achieved at a higher risk of fire and subsequent damage.

Hazards other than fire must also be taken into account when considering insulation and materials; for example, an improvement in thermal insulation will affect the thermal balance and might thereby create conditions in which interstitial or surface condensation can occur. Also, rain penetration might be induced through external cavity walls as a consequence of filling the cavity. These, and other possible risks, are not discussed in this digest but further information can be found in the list of further reading.

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Insulating materials, installed either during building or at a later stage to improve insulation standards, can be used within the cavity of external walls, as linings to the inner surfaces of walls and ceilings (and in a few cases to the external surfaces of walls), and in the roof space at ceiling joist level or fixed either to the rafters or directly to the underside of the roofing. Materials are available as loose fibres or granules which can be tipped or blown (as infill or cavity fill for example), as foam for injection into cavities, and as blankets, boards and flexible or rigid sheets. They may be non-combustible or combustible; the latter will burn in a fire and the more easily ignitable types could cause a fire to start if brought into contact with a heat scource such as a cigarette end, a naked flame (lighted match or blowlamp for example) or a defective electrical installation. Lightweight materials, such as fibres and foams, will generally ignite more easily than similar materials in solid form, and will contribute to rapid growth of a fire, whilst board materials used as linings can also contribute by spread of fire across their surface. Organic materials will produce toxic combustion products frequently accompanied by thick smoke.

However, an insulating material need not constitute a fire hazard because of its combustibility; it is its location and form that affect the risk. Some materials can be used safely as they are, others in conjuction with non-combustible materials. Foamed plastics insulation in a cavity brick wall is a good example of the safe use of a combustible material, provided the leaves have adequate fire resistance.

Care is needed, however, where combustible finishes are applied to insulating materials. Such finishes can create ideal conditions for surface fire spread; this applies irrespective of whether the isulating low-density subtrate is combustible or non-combustible.

Plastics materials will usually ignite or decompose when subjected to heat or fire producing heat, smoke and combustion gases. They are divided into two main groups:

Thermoplastic materials which soften and flow on heating, often before ignition takes place. Their fire behaviour will range from the situation where the softened material collapses or falls without ignition having taken place, to that where the material ignites and subsequently falls while burning. Examples are polystyrene, polypropylene, pvc and acrylics;

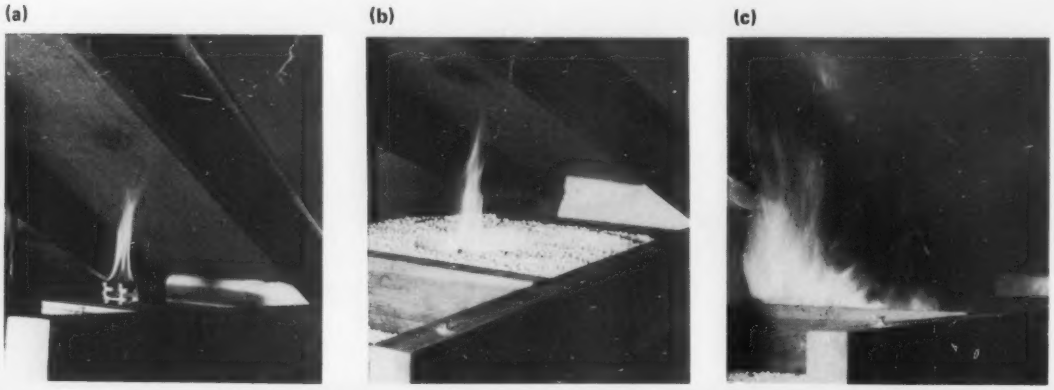
Thermosetting materials which do not soften but undergo localised charring, possibly with flaming combustion. Examples are urea formaldehyde, polyurethane and polyisocyanurate.

Fire tests

The tests based on product performance which are most frequently specified in legislation in the UK are those forming BS 476; they include the external fire exposure roof tests (Part 3:1958), the non-combustibility test for materials (Part 4:1970), fire propagation test for materials (Part 6:1968), surface spread of flame tests for materials (Part 7:1971) and test methods and criteria for the fire resistance of elements of building construction (Part 8:1972). However, these tests were developed primarily on the basis of experience with traditional materials (usually cellulosic) and are not appropriate for thermoplastics or for materials not used in rigid form.

The use of insulating materials in composite constructions, for example roofs and pre-formed wall panels, must satisfy the appropriate fire performances under the relevant parts of BS476; these usually include both material and constructional fire tests.

Fig 1 Loft floor insulation
(a) Ignition source on non-combustible base (no flame spread)
(b) Ignition source on combustible insulation (initial spread of flame over insulation)
(c) Ignition source on combustible insulation (ignition of sarking felt)



Sheet or board materials which are attached to a rigid construction often need to be protected by a non-combustible finish or board in order to satisfy the surface flame spread requirements. However, the surface flamability tests of BS 476:Parts 6 and 7 may not indicate the likely performance of the protection under fire conditions because the protective facing tends to remain in position due to the small scale of the experiment. For insulation products used other than as wall or ceiling linings, standard fire tests have considerable deficiencies; for example, the orientation of the specimen is often such that a horizontally laid product cannot be tested as used. Furthermore, the heating conditions prescribed in the tests are designed to simulate the severity of fire within a burning room or enclosure, and not to investigate the reaction of the material to a localised heat source of high or low intensity. Also, no test for smouldering has yet been adopted under BS476. However, the Fire Research Station has proposed methods of test designed to assess the ignitability and susceptibility to smouldering of loft insulating materials, developed for use as loose fill or in situ insulation between joists.

Non-combustible materials

Expanded perlite A lightweight material made from a siliceous glassy rock of volcanic origin, used for loose fill insulation.

Expanded vermiculite A lightweight exfoliated material produced from a flaky stone that closely resembles mica, which is used for loose fill insulation but is also available in board form.

Mineral fibre insulating materials Products which are manufactured from glass fibre, slagwool and rock fibre. These products can be used as small tufts which can be blown into voids or poured into joist spaces. The addition of binders enables the fibres to be formed into a blanket (or mat) which can be easily stapled to partition studs of new construction, or laid between or over joists. Materials with paper facings or with more than a minimum amount of resinous binder are combustible. Blankets are also available with plain wire or wire mesh reinforcement.

Combustible materials

Cellulose fibre Produced by shredding waste paper or wood. Without additives the material can be ignited by a match or a cigarette and it will then burn or smoulder persistently. Effective retardant chemicals are needed to prevent smouldering; appropriate additives are currently available to inhibit ignition from a flame, unless the source is large. Some chemicals will cause corrosive attack on metals such as copper or galvanised steel.

Polystyrene (expanded or foamed) A thermoplastic material which will melt and shrink away from a small heat source. If the heat source is large ignition will be followed by severe flaming and rapid emission of heavy black smoke. Polystyrene melts as it burns, resulting in flaming droplets and puddles of burning material. The addition of flame retardant additives

Fig 2 Progressive smouldering through combustible loft insulating material

increases the resistance of the molten polystyrene to ignition and reduces the risk of flaming drops but does not make the product non-combustible. The material is formed from beads which are available as loose fill or in bags, or, in board form, as extruded foam and bead board. In loose fill form, it is available with an adhesive additive to prevent it flowing into a fire if containment is breached.

Wood fibre insulating board (softboard) Non-compressed sheets formed of wood or woody plants reduced to fibres which are then felted together to form a low-density material with thermal and acoustic insulating properties. Untreated board has a Class 4 rating under BS 476: Part 7 but this can be improved to Class 1 with surface coatings or by impregnation; such boards are available commercially.

Plasterboard A non-combustible core with paper facings which achieves Class 1 under BS 476: Part 7 and $I \leq 12$, $i_1 \leq 6$ under BS 476: Part 6. It is also available with a veneer of polished aluminium foil on one face or as a laminate with polymeric foam materials such as expanded polystyrene, polyurethane and phenol formaldehyde.

Polyurethane (expanded or foamed) A thermosetting plastics material which is usually treated to prevent ignition by a small source such as a match flame. Exposed to a larger flame, however, ignition will occur and fire can spread very rapidly, with the production of abundant smoke and toxic decomposition products. It is available in the form of irregular shaped chips as loose fill or in bags.

Polyisocyanurate A modified polyurethane reasonably resistant to all but large ignition sources; smoke and decomposition products are similar to those of polyurethane. It is available in board form.

Urea-formaldehyde (foamed) A thermosetting plastics material which will produce brief duration flames up to a short distance from an ignition source: charring of the surface prevents sustained flaming. This foam insulation has litle mechanical stability which restricts its use mainly to situations such as cavity fill but it can also be used for loft insulation. Pre-formed boards are also available.

Phenolic foam A thermosetting plastics material not easily ignited by a small ignition source. Some types may exhibit smouldering or glowing after extinction of the igniting flame. Available as loose chips and board.

Recommendations for use

With few exceptions (eg non-combustible products or combustible materials, often incorporating flame retardants, tested for acceptability in suitable situations) no insultation material should be left exposed directly to the habitable areas of a building. It should at all times be protected from all sources of heat which could be likely to cause ignition. Suggested means of protection for many foamed plastics insulating materials include plasterboard or one of the asbestos-free substitutes. Any protection over insulating materials which soften at low temperatures should be independently fixed (eg nailed to battening) so that softening of the insulation does not result in premature coliapse of the protective material.

Before undertaking extensive insulation, the electrical system of a house should be checked as certain cellular plastics, such as urea formaldehyde foam which is pumped in wet, could cause serious problems. There could also be an interaction between the pvc sheathing on electrical cables and expanded polystyrene; whilst not likely to cause a serious problem if the degraded sheathing is left undisturbed, the two materials are best kept apart by appropriate siting of the cables or the use of conduit. Additionally, electric wiring should, as far as possible, be kept above the level of loft insulation to reduce the risk of overheating.

Roof Spaces

Materials used in the construction of the loft area are not subject to any control on the basis of their likely fire behaviour. The present requirements are concerned only with such criteria as the structural suitability of materials, the weather-proofing of the roofing, etc.

The most common and probably most satisfactory way of insulating a loft is to cover the exposed upper surface of the ceiling. This can be done by laying mineral fibre mats or filling the spaces between the joists with granules but the thickness required of some of the materials to achieve an adequate insulation standard will bring them well above joist level. Possible sources of ignition in these insulating layers include overheated and defective chimneys, overheating electric equipment (eg inset lighting fixtures), sparks from defective wiring, small flames or smouldering resulting from poorly executed or supervised repair work, carelessly discarded cigarette ends or the misuse of other heat or light sources. Ignition of the combustible insulation may result in ignition of other flammable materials (particularly the sarking felt) which might not be easily ignited by the initial source itself. The use of insulation in this way is likely to result in an increase in the number of fires originating in the loft area. Examination of the pattern of loft fires in recent years suggests that whilst the casualty rate from such fires is very low, an increase in material damage is likely.

Alternatively, insulation may be fixed to the underside of the rafters. If this is the case care must be taken to ensure roof ventilation. Expanded polyurethane foamed in situ on the underside of the tiles, or sheets of expanded plastics, used in this way may ignite easily. There will be, therefore, an increased risk of sustained burning, flame spread, overall production of heat and the evolution of smoke and other combustion products if a fire starts in the contents of the roof space. Such insulated surfaces can be treated to improve resistance to ignition but better protection is provided by solid non-combustible sprayed finishes based on vermiculite and mineral fibre, or by plasterboard or plaster supported on wire mesh. Other foamed plastics such as polyisocyanurate or phenolic foam have improved fire properties and even without retardant treatment compare favourably in terms of ignitability with traditional sarking felt.

Cavity walls

The fire hazard of combustible insul ation contained within double leaf masonry external walls is minimised as the brick or block work is unlikely to fail in a fire. If the insulation fully fills the cavity (eg pumped urea-formaldehyde or polyurethane foam) accidental localised exposure to fire of the insulation, such as might result from failure of a thermoplastic pipe, is unlikely to result in rapid or extensive flame spread. Where plastics in board form are used for insulation of a masonry cavity wall (eg expanded polystyrene in new construction) the restricted ventilation combined with the massive facings restrict active flaming to the area round the point of failure but smoke and decomposition products are likely to diffuse through the cavity or, if perimeter cavity barriers are inadequate, may percolate into the loft or even into habitable areas. The same problem results if granular or bead products are used.

Fig 3 Decomposition of urea-formaldehyde cavity fill following breach of masonry leaf (outer leaf removed)

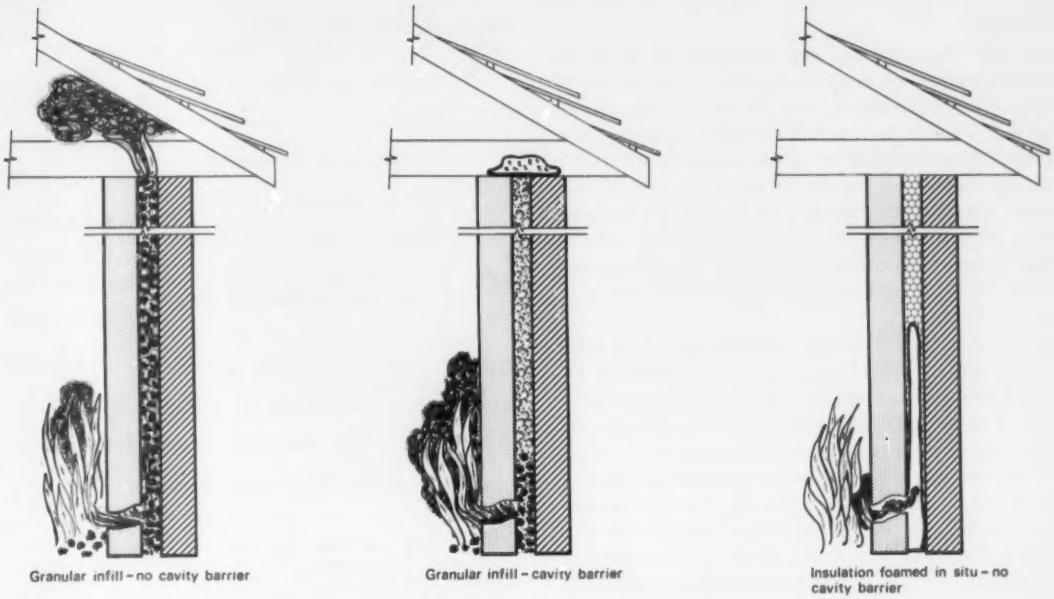


Fig 4 Effect of localised fire penetration of insulated cavity walls

Room linings.

As mentioned earlier, any flammable insulating material left exposed generally constitutes a fire risk: the insulating characteristics of the materials encourage a rapid temperature rise on their exposed surfaces which accelerates flame spread; this applies particularly to thermosetting resins. The fire behaviour of some thermoplastic materials may lead to the release of burning droplets, which in turn ignite contents in the room beneath the ceiling.

Tests have shown that although polystyrene is flammable, if tiles made of this material (not exceeding 12.5mm thick) are attached by overall adhesive to a non-combustible ceiling and left undecorated, there is no serious fire hazard. This applies to both the standard and the flame-retardant treated products. However, rapid fire spread can ocur if tiles which are poorly attached to the surface, or have been decorated with gloss paint, are ignited. A flaming polystyrene or paint-polystyrene film can fall causing serious fire spread in the room below. Such tiles should therefore be removed. If over-painting is considered essential, only matt finish flame-retardant or water-based emulsion paints should be used.

Fig 5 Melting and detachment of incorrectly-fixed polystyrene tiles.

Services

CP 413 recommends that combustible materials should either have satisfactory performance in case of fire, or be so contained that fire and smoke cannot spread. Internal linings to ventilation ductwork, and insulation on the exterior where the ductwork is concealed in service areas, should be non-combustible or when tested in accordance with BS 476:Part 6 should have an index of performance $I \leq 12$ and $i \leq 6$. Where high-temperature ductwork (over 230 °C) is to be insulated, BS 5422 requires a non-combustible material to be provided.

Mineral wool and glass fibre materials with a low resin binder content can be rated non-combustible by BS 476: Part 4 and will not, in isolation, support combustion. A combustible protective covering, such as canvas, does however present a risk of spread of fire over the surface and although the use of a flame retardant paint will improve the performance, the combination may not achieve the recommended rating on BS476: Part 6. The same is true of a finishing film of pvc or polyethylene or any thin combustible finish supported on an insulating substrate. In any event, combustible insulation on the exterior of the duct may not be carried through a fire division and it is recommended that where used internally it should be terminated at a point 1 m from a fire damper.

BS5422 contains further recommendations concerning the fire hazard of thermal insulating materials associated with refrigeration applications, chilled and cold water supplies, central heating and domestic hot and cold water supply installations, and with process pipework and equipment applications.

REMEMBER

THINK before selecting an insulating material. Do you have information on its fire behaviour? IF NOT, ask for it.

Non-combustible materials are safer

Some combustible materials can be used safely, but check their properties first.

CHECK wiring for loose connections or damaged electrical insulation.

In the roof space -

Do NOT SMOKE

Do NOT use candles or other heat source liable to start a fire.

Use blow-lamps with UTMOST CARE

References and further reading

BS 476: Fire tests on building materials and structures:

External fire exposure roof tests
BS 476: Part 3: 1958

Non-combustibility test for materials
BS 476: Part 4: 1970

Ignitability test for materials
BS 476: Part 5: 1968

Fire propagation test for materials
BS 476: Part 6: 1968

Surface spread of flame tests for materials
BS 476: Part 7: 1971

Test methods and criteria for the fire resistance of elements of building construction
BS 476: Part 8: 1972

BS 5422: 1977 Specification for the use of thermal insulating materials

BS5803: Thermal insulation for pitched roof spaces in dwellings
Part 1:1979 Man-made mineral fibre thermal insulation mats

BS CP 413: 1973 Ducts for building services

Building and buildings. The Building Regulations 1976. Statutory Instruments 1976 No 1676; HMSO; London

Building and buildings. The Building (First Amendment) Regulations 1978, Statutory Instruments 1978 No 723; HMSO; London

Building and buildings. The Building Standards (Scotland) Regulations 1971 to 1979. Statutory Instrument 1971 No 2052, 173 No 794, 1975 No 404 and 1979 No 310; HMSO; London

Homes Insulation Act 1978. Ch 48; HMSO; London

Plastics in buildings - fire problems and control; Barbara Rogowski; BRE Current Paper CP 39/76

Polymeric materials in fires; BRE Current Paper CP91/74

Aids to the identification of plastics; BRE Kit

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Department of the Environment **Building Research Establishment**

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Published by Her Majesty's Stationery Office and printed litho in Wales by The Five Arches Press, Tenby, Dyfed.
Single copies 16p each. Annual subscription inclusive of postage £2.88 for 12 monthly issues and new editions of earlier Digests.
Quantity rate (excluding postage) for bulk supply of any one Digest: 50 for £6.40

Dmd. 596159 ISBN 0 11 725039 2

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